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SERIES 60 CONTROL
USING 3-ACTION D.A.T. CONTROL UNIT

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SERIES 60 CONTROL

USING 3-ACTION D.A.T. CONTROL UNIT

INTRODUCTION

In general, a Series 60 Duration-Adjusting Type (D.A.T.) control system comprises an arrangement of the following major components:

(1) A primary element sensitive to the variable quantity to be controlled. Since duration-adjusting controllers are ordinarily used only for temperature applications, the primary element is usually a thermocouple or a Thermohm® detector.

(2) A recorder or indicator which measures the output of the primary element. This instrument, which also contains a control setting device, signals the control unit whenever the measured variable departs from the set point.

(3) A control unit which automatically adjusts the percentage "On" time of the final control element to correct for temperature variations from the set point. The amount of proportional, reset, and rate action provided by the control unit may be adjusted to give proper response of the final control element for the particular process being controlled.

(4) A final control element. Usually this is a contactor supplying power to an electric furnace. For control of fuel-fired processes, however, the final control element may be a solenoid valve, or a valve operated by an electric drive mechanism.

This booklet is intended to apply primarily to the control unit. Information on other components of the system is included only where it pertains to their relationships with the control unit. For more complete information on these other items, the user is referred to other booklets furnished with the equipment.

PART I

DESCRIPTION OF EQUIPMENT

1. APPLICATION

The three-action D.A.T. control unit is normally used for automatic control of electric furnaces, but may also be used on fuel fired furnaces, in conjunction with an electrical drive unit, on any application where a percentage-time, proportional control unit with automatic reset and rate-time action is required.

The duration-adjusting type control unit provides variations in the time duration of the impulses which heat the furnace by turning the heat ON and OFF in proportion to variations in temperature from the control point. With temperature stationary at the control point, the percentage of ON and OFF time is constant; if temperature drops below the control point, the percentage of ON time increases; if temperature rises above the control point, the percentage of ON time decreases. The three control actions (proportional, reset, and rate) cause the percent ON time to change according to (1) the magnitude, (2) the duration, and (3) the speed, of departures from control point.

2. EQUIPMENT VARIATIONS

The Series 60 three-action D.A.T. control unit comprises a chassis arranged to plug into an outer case. Both the chassis and the case arrangements may vary, as follows:

(1) The control unit chassis may be Part No. 354165 or Part No. 354182. These parts differ only in that the former is for use with a 120 V, 60 cycle line supply, while the latter requires a 120 V, 50 cycle supply. The chassis are identical in external appearance (see Fig. 3).

(2) The control unit may be supplied as part of a Speedomax® H indicating or recording controller, or it may be furnished as a self-contained unit for use with a Speedomax G or Micromax® recorder. In the former instance, the control unit chassis plugs into the lower case of the Speedomax H long door instrument, the door being common to both cases as shown in Fig. 1. The assembly is furnished complete with all necessary wiring between the two cases. Thus the control unit is an integral part of the Speedomax H instrument.

When supplied for use in conjunction with a Micromax or Speedomax G recorder, the control unit is provided with its own case, as shown in Fig. 2, for mounting separate from the recorder. In this arrangement the unit is identified by a catalog number which varies according to the chassis contained in the case. Thus if the chassis is part #354165, the control unit is Cat. 10879; if the chassis is part #354182, the control unit is Catalog 10879-F.

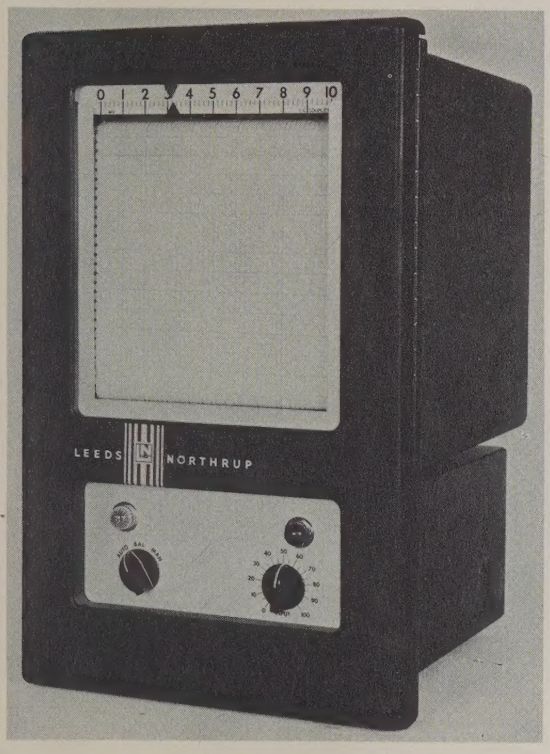


Fig. 1 - Speedomax Type H long door instrument with control unit in lower case.

3. FUNCTION OF PANEL CONTROLS AND INDICATORS

All switches, dials, and indicating devices used in adjusting and operating the control unit are contained on the chassis front panel. Those commonly employed when the equipment is in service are available at all times through the opening in the control unit door, as shown in Figs. 1 and 2. Dials used for initial tuning of the control (and only infrequently thereafter), are concealed except when the door is opened, to prevent them from being disturbed during normal operation.

Functions of the various controls and indicators are as follows:

A. AUTO-BAL-MAN Switch

With this switch turned to MAN, the control unit can be operated as a remote manual controller. With switch in the AUTO position, the control unit functions as an automatic controller. Transfer from manual to automatic operation is accomplished without abrupt change of process input, simply by pausing momentarily in the BAL position before turning to AUTO. This "bumpless" transfer is obtained regardless of whether the controlled variable is at control point or away from it.

B. INPUT Dial

This dial is effective only when the AUTO-BAL-MAN switch is on MAN, and then it is used for remote manual control of process input. The dial setting is equal to the percent ON time of process input.

C. Signal Lights

The amber signal light glows when the system is on automatic control and process temperature is above the safety switch setting (see 4B). The red signal light glows when the process input is on.

D. PROPORTIONAL BAND Dial

Proportional control is a control action in which the change in per cent

Fig. 2 - No. 10879 Control Unit

ON time is proportional to recorder* pen motion. The ratio of pen motion to change in % ON time is expressed as the proportional band and is adjusted by means of the PROPORTIONAL BAND dial. A dial setting of 10%, for example, means that the recorder pen must travel over 10% of the recorder scale to vary the % ON time from 0% to 100% (i.e., continuously OFF to continuously ON).

E. RESET Dial

Automatic reset provides floating correction of % ON time at a speed proportional to the deviation of the recording pen from the control point setting. The ratio of speed to deviation is adjustable by means of the RESET dial. This control action causes the % ON time to change slowly as long as the recorder pen is off control point. At control point it stops.

Proportional action alone will not maintain the recorder pen at the control point when process demand changes are encountered. The proportional control provides the rapid and stable response to process demand

*Although the control unit may be used in conjunction with an indicator, a recorder is more often employed. Therefore, for convenience, the term "recorder" is used in this and subsequent sections, and shall be understood to mean "recorder or indicator".

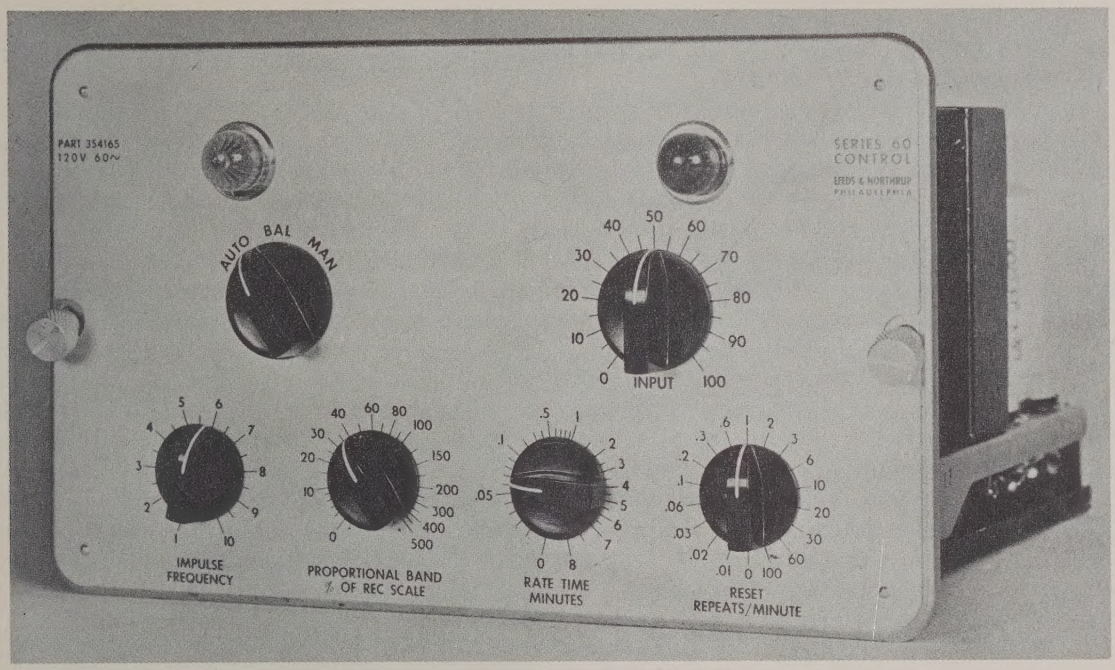


Fig. 3 - Control Chassis

changes which are required for close control. When reset action is superimposed upon proportional control, it provides the recognition of control point which simple proportional control lacks.

Reset rate is calibrated in "repeats per minute", which term may be explained as follows:

Suppose the recorder pen is at control point. Now suppose that the recorder pen moves away from control point so that the proportional action increases the % ON time by, say, 10%. Suppose then that the recorder pen is held steady at this position. The reset action will now further increase crease the % ON time at a rate proportional to the distance the recorder pen is off control point.

If the RESET dial is at 1.0, then in one minute reset action will add another 10% to the % ON time. That is, the reset action will "repeat" the proportional action once per minute.

F. RATE TIME Dial

Rate action applies a correction to the % ON time which is proportional to the rate of change of recorder pen position. This corrective action, when used in conjunction with proportional and reset action, aids in overcoming the effects of process capacity and measuring lags which give the process a tendency to overshoot or cycle about the control point. The amount of rate-time action depends upon the RATE-TIME dial setting.

The RATE TIME dial is calibrated in minutes. The significance of the dial setting is as follows:

Suppose that the recorder pen is moving downscale from the control point at a constant rate. Then, because of proportional action, %ON time will increase--also at a constant rate. Thus, for a given set of conditions, % ON time might increase at the rate of, say, 3% per minute due to proportional action only. Now, if the RATE TIME dial were set at 2 minutes, the % ON time would increase by an additional amount equivalent to 2 minutes of proportional action, i.e. a 6% increase, in the example cited.

G. IMPULSE FREQUENCY Dial

Although the percentage of ON time is adjusted in response to process conditions, the actual duration of the ON-OFF impulse cycles depends upon certain other factors. The gain of the control unit amplifier is one such factor. Thus the repetition rate (frequency) of ON impulses can be adjusted by means of the IMPULSE FREQUENCY dial, which is actually an amplifier gain control. This dial is arbitrarily calibrated 1 to 10, with higher settings producing higher impulse frequencies.

The range of the IMPULSE FREQUENCY dial depends upon the position of a jumper on the control unit terminal board. Either a low or a high range may be selected, according to process requirements. Since impulse frequency is also affected by the proportional band setting, no simple statement of the high and low range limits is possible. However, for a typical proportional band setting of 20%, the low range provides impulse rates from 3 to 50 per minute (approximately), while the high range provides rates from 24 to 140 per minute (approximately). With a smaller proportional band setting, the ranges are higher, and conversely.

4. OTHER FEATURES

A. Rate Of Approach

The control unit circuitry is so arranged as to provide automatic cut-back of control action (rate-of-approach) prior to attainment of control point at start-up. That is, the % ON time starts to decrease before the control point is reached, thereby reducing or preventing overshoot. This feature is entirely automatic, requiring no special setting or manipulation by the operator.

B. Safety Action

A cam-operated switch, located in the recorder, is arranged so that in the event of excessively high values of the controlled variable, the process input is turned off (on automatic operation only). At the same time, the amber signal light on the control unit goes on. If desired, the safety action will also energize an external alarm (see installation diagram). The safety action completely bypasses the control unit and, therefore, will protect against any type of control unit failure.

C. Line Voltage Compensator Switch

This switch is located under the control unit chassis. It has two positions, E and F, standing for "electric" and "fuel" respectively. The position of the switch determines the type of line voltage compensation provided by the unit, as follows:

(a) With the E-F switch in the E position, the control unit automatically compensates for variations in the electric furnace power supply voltage. That is, any drop in furnace supply voltage causes an immediate compensating increase in the percent ON time, and conversely. The switch is placed in the E position before shipment and therefore need not be changed if the unit is to be used on an electric furnace.

(b) With the E-F switch in the F position the control unit is compensated so that line voltage variations produce no corresponding change in percent ON time. This is the condition required for fuel-fired processes.

PART II

INSTALLATION AND OPERATION

5. UNPACKING

After removing the instrument from its packing case, loosen the chassis fasteners located at each side of the front panel. This is accomplished by turning the knurled fastener heads counterclockwise. The chassis can now be pulled forward out of the case. Remove and discard all packing material and shipping ties from the chassis. Then make sure all plug-in parts are seated firmly in their sockets, before replacing the chassis in the case.

IMPORTANT: If for any reason the control unit is to be sent back to Leeds & Northrup Company, it must be properly packed to prevent damage during shipment. If the original packing material and shipping ties have been removed, all plug-in components should be taken out of their sockets, wrapped separately, and shipped in the same container as the control unit.

6. MOUNTING

(1) If the control unit is supplied as part of a Speedomax H indicating or recording controller, follow the mounting instructions given in the Speedomax H manual.

(2) If the control unit is supplied in a separate case, it should be mounted in a readily accessible location near the recorder (usually directly below the recorder on the panel). The control unit is arranged for flush mounting only. Fig. 4 gives all necessary mounting dimensions.

7. TEMPERATURE LIMITS

The control unit should not be installed in locations where the ambient temperature goes outside the limits 16F to 122F (-9C to 50C).

8. OTHER EQUIPMENT

For instructions on installing the recorder, drive mechanism, control valve, and any other components of the control system, refer to the booklets furnished with such equipment.

9. WIRING CONNECTIONS

Wiring connections to the various units of the control system are to be made in accordance with the diagram furnished for the system. Special attention should be given to all notes on the diagram.

Figs. 5 and 6 show wiring diagrams of control systems employing Speedomax H and Speedomax G measuring instruments respectively. These circuits show the most frequently used Series 60 D.A.T. control arrange-

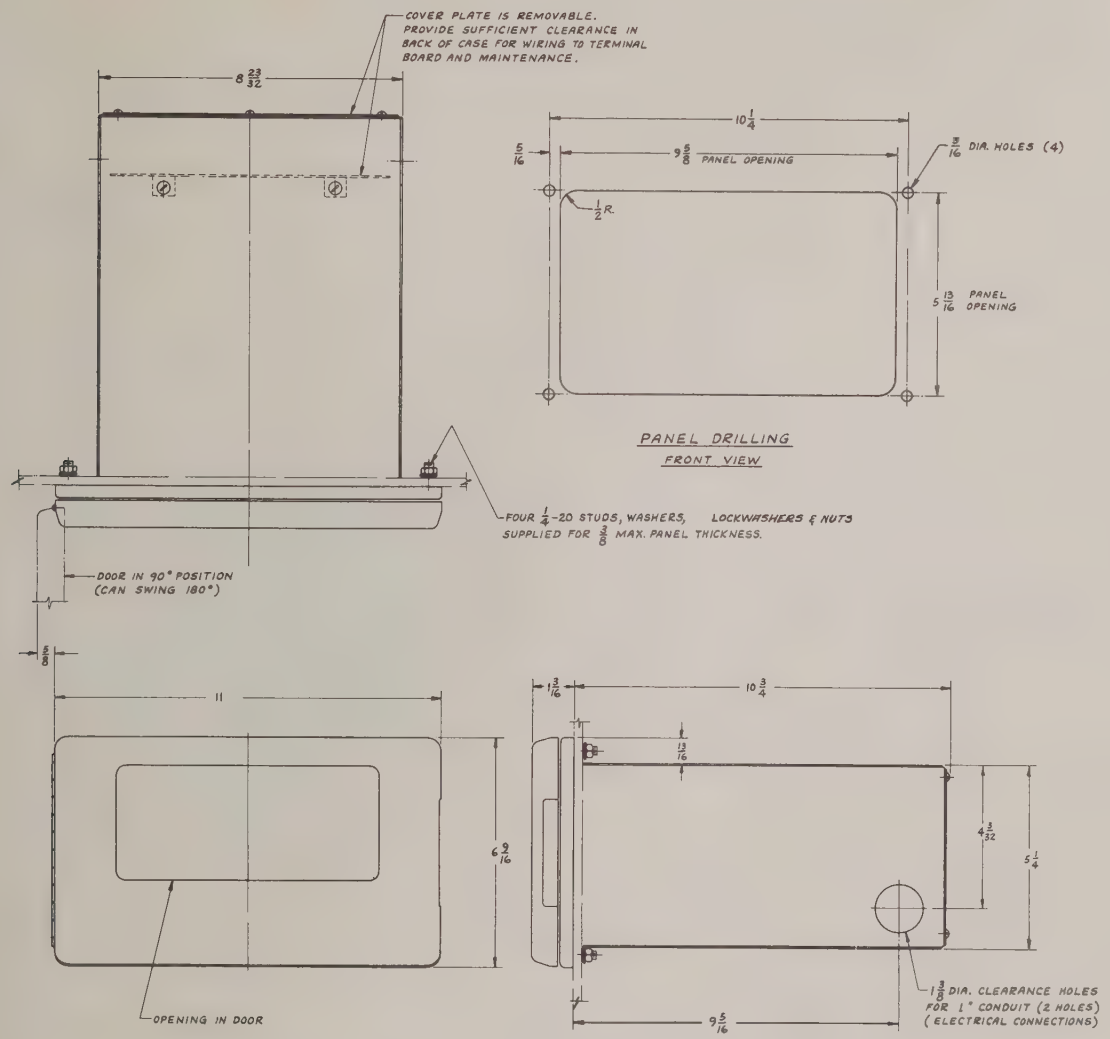

COVER PLATE IS REMOVABLE. PROVIDE SUFFICIENT CLEARANCE IN BACK OF CASE FOR WIRING TO TERMINAL BOARD AND MAINTENANCE.
8 23/32
10 1/4
5/16
9 5/8 PANEL OPENING
3/16 DIA. HOLES (4)
1/2 R.
5 13/16 PANEL OPENING
PANEL DRILLING
FRONT VIEW
FOUR 1/4-20 STUDS, WASHERS, LOCKWASHERS & NUTS SUPPLIED FOR 3/8 MAX. PANEL THICKNESS.
DOOR IN 90° POSITION (CAN SWING 180°)
11
6 9/16
OPENING IN DOOR
1 3/16
10 3/4
13/16
4 3/32
5 1/4
1 3/8 DIA. CLEARANCE HOLES FOR 1" CONDUIT (2 HOLES) (ELECTRICAL CONNECTIONS)
9 5/16

Fig. 4 - Outline and mounting dimensions for control unit

ments, and the diagrams are reproduced here for convenient reference. Actual and schematic internal diagrams of the control unit are shown in Figs. 17 and 18.

10. PRELIMINARY CHECKS AND ADJUSTMENTS

After the installation is completed, the operation of each component of the control system should be checked before the equipment is put into actual service. The preliminary checks and methods of adjusting the various components for control of the process are discussed in the following paragraphs.

A. Recorder Or Indicator

Check the recorder to be sure that it is recording and indicating the

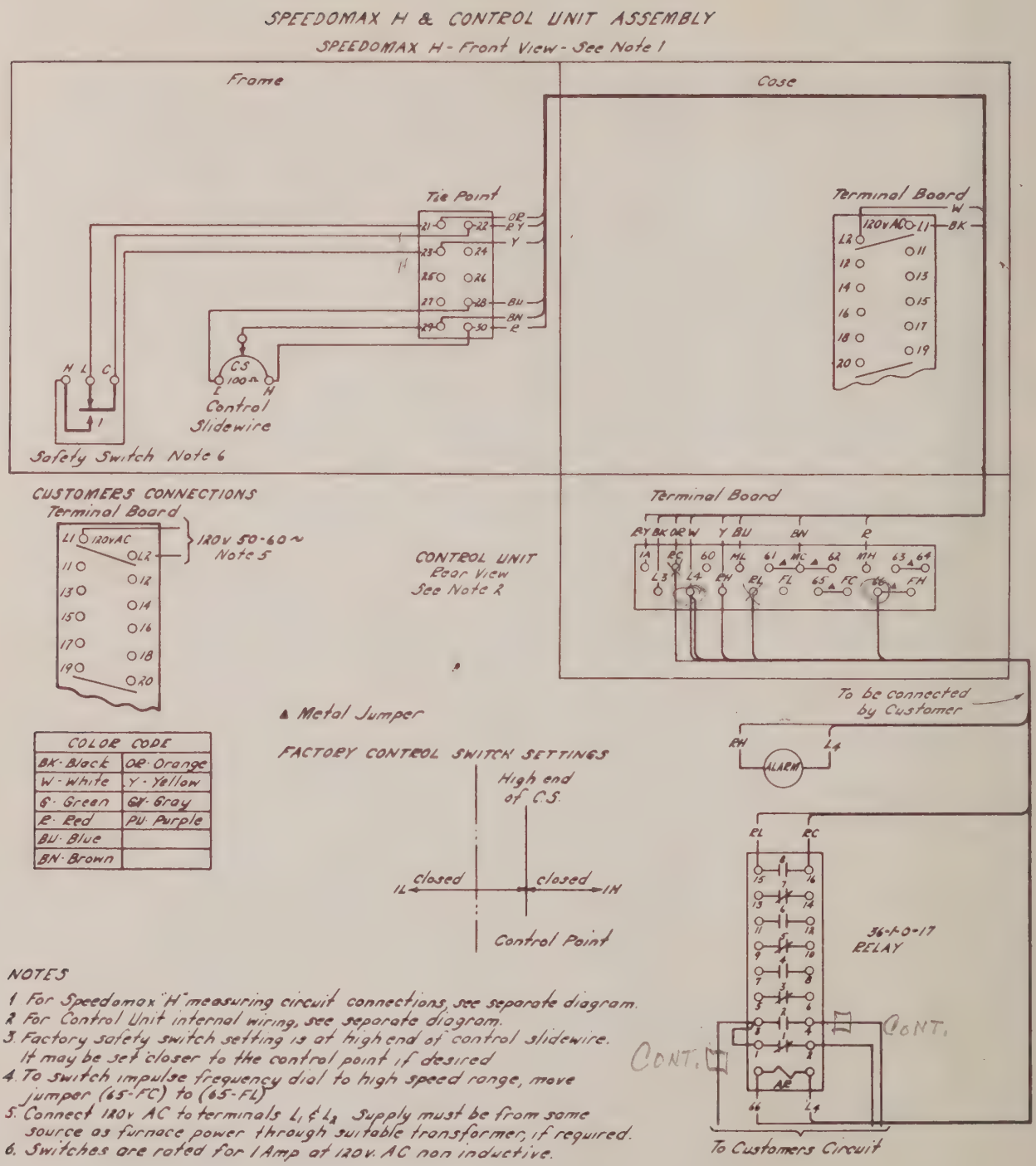

SPEEDOMAX H & CONTROL UNIT ASSEMBLY
SPEEDOMAX H - Front View - See Note 1
Frame
Case
Tie Point
Terminal Board
Safety Switch Note 6
Control Slidewire
CUSTOMERS CONNECTIONS
Terminal Board
120v 50-60~ Note 5
CONTROL UNIT Rear View See Note 2
Terminal Board
▲ Metal Jumper
To be connected by Customer
COLOR CODE
BK - Black
W - White
G - Green
R - Red
BU - Blue
BN - Brown
OR - Orange
Y - Yellow
Gy - Gray
PU - Purple
FACTORY CONTROL SWITCH SETTINGS
High end of C.S.
closed
closed
IL
IN
Control Point
ALARM
36-1.0-17 RELAY
CONT.
CONT.
To Customers Circuit
NOTES
1. For Speedomax "H" measuring circuit connections, see separate diagram.
2. For Control Unit internal wiring, see separate diagram.
3. Factory safety switch setting is at high end of control slidewire. It may be set closer to the control point if desired
4. To switch impulse frequency dial to high speed range, move jumper (65-FC) to (65-FL)
5. Connect 120v AC to terminals L1 & L2. Supply must be from same source as furnace power through suitable transformer, if required.
6. Switches are rated for 1 Amp at 120v. AC non inductive.

Fig. 5 - Wiring connections for Series 60 3-action D.A.T. control with Speedomax Type H.

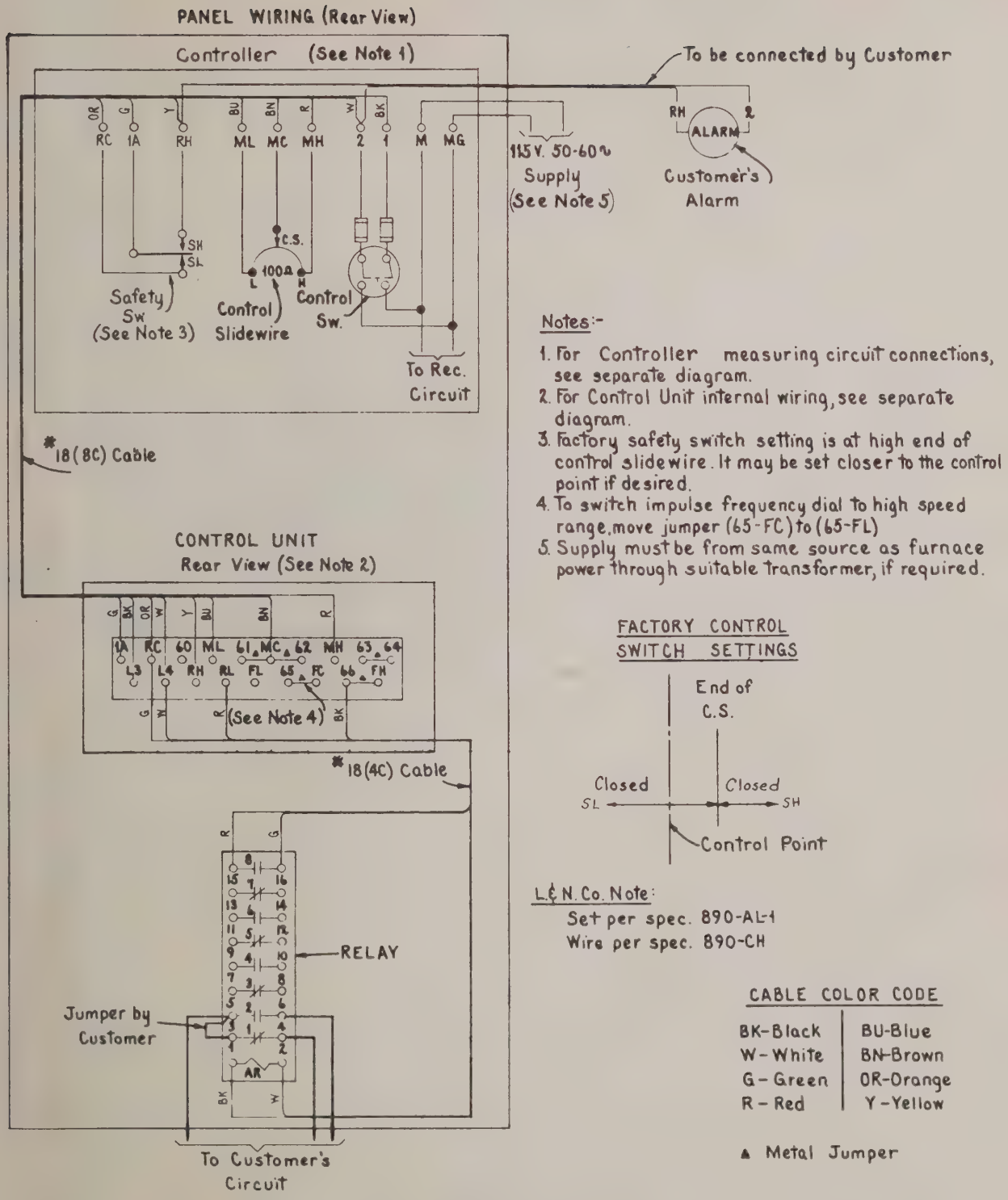

PANEL WIRING (Rear View)
Controller (See Note 1)
To be connected by Customer
OR G Y BU BN R W BK
RC 1A RH ML MC MH 2 1 M MG
RH 2
ALARM
115 V. 50-60 ~ Supply (See Note 5)
Customer's Alarm
SH
SL
C.S.
100Ω
L H
Safety Sw (See Note 3)
Control Slidewire
Control Sw.
To Rec. Circuit
*18(8C) Cable
CONTROL UNIT
Rear View (See Note 2)
G BK OR W Y BU BN R
1A RC 60 ML 61 MC 62 MH 63 64
L3 L4 RH RL FL 65 FC 66 FH
(See Note 4)
*18(4C) Cable
RELAY
Jumper by Customer
AR
To Customer's Circuit
Notes:-
1. For Controller measuring circuit connections, see separate diagram.
2. For Control Unit internal wiring, see separate diagram.
3. Factory safety switch setting is at high end of control slidewire. It may be set closer to the control point if desired.
4. To switch impulse frequency dial to high speed range, move jumper (65-FC) to (65-FL)
5. Supply must be from same source as furnace power through suitable transformer, if required.
FACTORY CONTROL SWITCH SETTINGS
End of C.S.
Closed
Closed
SL
SH
Control Point
L & N. Co. Note:
Set per spec. 890-AL-1
Wire per spec. 890-CH
CABLE COLOR CODE
BK-Black
W-White
G-Green
R-Red
BU-Blue
BN-Brown
OR-Orange
Y-Yellow
▲ Metal Jumper

Fig. 6 - Wiring connections for Series 60 3-action D.A.T. control with Speedomax Type G.

output of the primary element properly. During this check the CONTROL ON-OFF switch can be placed in the OFF position, if such a switch is provided. If the recorder is a Speedomax H instrument having no CONTROL ON-OFF switch, the control may be turned off by removing the control unit chassis from its case.

Check the setting of the safety switch which is located in the recorder. This switch is usually set to operate when the control slidewire contact is at the high end of the slidewire, but may be adjusted to operate for a recorder reading nearer to the control point, as indicated on the diagram. If operation is not correct, adjust the switch as instructed in the booklet furnished with the instrument.

The shunting effect of the 470 ohm resistor between the ML and MC terminals of the control unit (see schematic diagram) causes an effective unbalance of approximately 2.5% of the control slidewire when the control slidewire contact is at the center of the slidewire. To compensate for this effect, the control slidewire is shifted to position the control slidewire control slightly off center toward the MH end when the red and black pointers are together. If this adjustment is disturbed it can be readjusted by following the instructions given below.

(1) Line up the red and black pointers of the recorder and turn the CONTROL ON-OFF switch to ON, or plug the control unit chassis back into its case if it has been removed during preceding steps.

(2) Connect a d-c milliameter (or Simpson Model 260 analyzer connected as a milliammeter) between terminals MC and G3 of the control unit terminal board. Initially the meter should be on the 100 milliampere range.

(3) While keeping the red and black pointers together, adjust the control slidewire to reduce the milliampere reading to zero. As the zero reading is approached, switch the meter to progressively lower ranges. Final adjustment should be made on the 100 microampere range.

B. Control Unit

(1) E-F Switch

If the control unit is to be used on a fuel-fired process, pull the chassis out of its case, remove the bottom cover, and snap the E-F switch to the F position.

(2) Manual Operation

(a) Start the recorder operating and set the control point index at the desired control point.

(b) Set the dials in the control unit at the following initial settings:

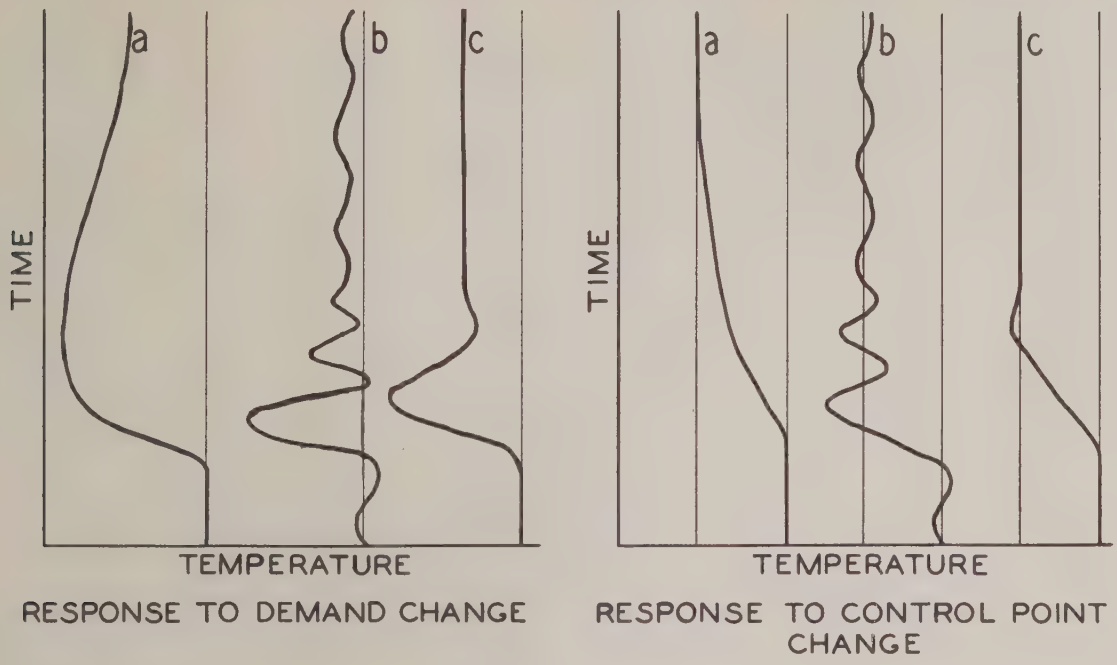


Fig. 7
Effects of Proportional Band adjustment: Curves (a), Proportional Band too wide; curves (b), Proportional Band too narrow; curves (c), Proportional Band correct.

PROPORTIONAL BAND	50
RESET	0
RATE TIME	0
IMPULSE FREQUENCY	5

(c) Set the MAN-AUTO switch to MAN.

(d) Snap the control switch to ON or plug the control unit back into its case if it has been removed during preceding steps.

The process can now be controlled by means of the INPUT dial. It should be operated this way for a time and the nature of the record noted carefully. If excessive cycling occurs during manual operation, the cause should be investigated and eliminated, if possible, before the transfer to automatic control is made.

(3) Transfer to AUTO

To transfer to automatic control turn the AUTO-BAL-MAN switch. Pause for at least one second in the BAL position before switching to AUTO. This will adjust the control circuit so that the transfer can be made without upsetting the process.

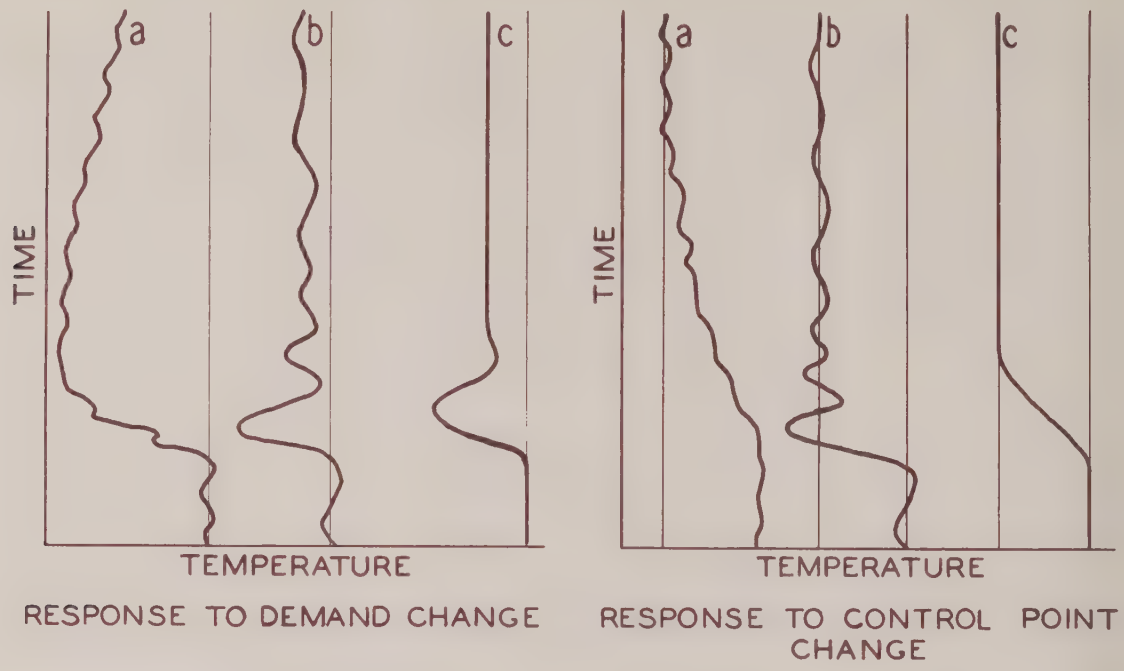


Fig. 8
Adjustment of Proportional Band and Rate Time: Curves (a), Proportional Band too wide, Rate Time too long; curves (b), Proportional Band too narrow; curves (c), both correct.

(4) IMPULSE FREQUENCY Setting

In general, it is desirable that the impulse frequency be low, in order to extend the life of the power contactor or other final control device. However, if the impulse frequency is too low, the process will respond to individual impulses, with consequent cycling about the control point.

Thus the IMPULSE FREQUENCY dial should be turned to the lowest value which does not cause the controlled temperature to cycle. On some processes, the impulse frequency may not be great enough even when the dial is at its highest setting. In this event a higher range of frequencies can be obtained by moving a jumper as directed on the installation wiring diagram.

The impulse frequency is also affected by the setting of the PROPORTIONAL BAND dial. Therefore when the proportional band is changed, it may be necessary to readjust the IMPULSE FREQUENCY dial as instructed above.

11. ADJUSTING CONTROL UNIT TO A PROCESS

While there are several methods of predicting approximate control settings by observing process performance, such methods are often difficult and do not always yield best results. A more practical means of se-

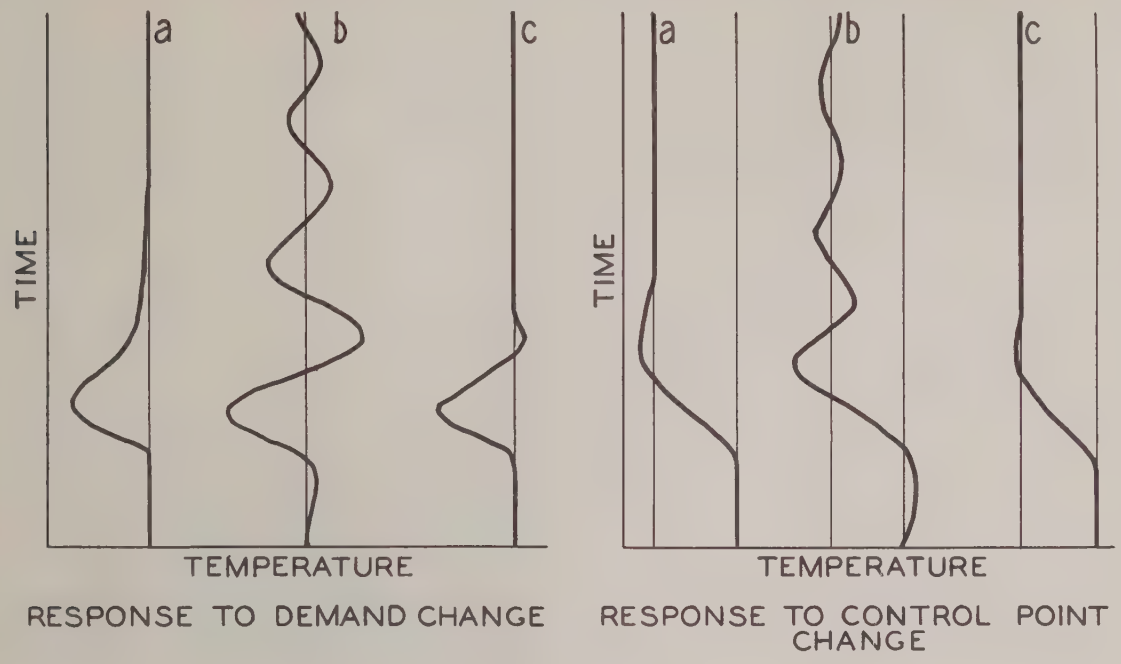


Fig. 9
Effect of Reset Adjustment in proportional-plus-reset control: Curves (a), reset too slow; curves (b), reset too fast; curves (c), reset correct.

curing good control adjustments is to use a systematic experimental approach. One recommended approach is outlined in this section.

In adjusting any controller, and particularly a temperature controller, there is no substitute for patience. Adjustments made too close together, without allowing time for conditions to stabilize, very frequently lead to incorrect conclusions and an overall loss of time in producing a final adjustment. On some processes where the operating conditions vary widely, it may be necessary to make adjustments which are a compromise in order to meet this wide range of conditions. In practically all cases, it is good practice to avoid tuning a controller so that it is on the verge of a cycling condition, because minor changes in conditions on the job, such as a slight change in pressure in the fuel system or a deposit on the thermocouple which increases the measuring lag, will throw the control into a cycle. Good controller adjustments are those which produce satisfactory results and still retain stability.

After the best control settings have been determined they should be recorded, in order to facilitate resetting in case adjustments are disturbed. A label is provided inside the door, facing the control unit panel, with spaces for noting the settings.

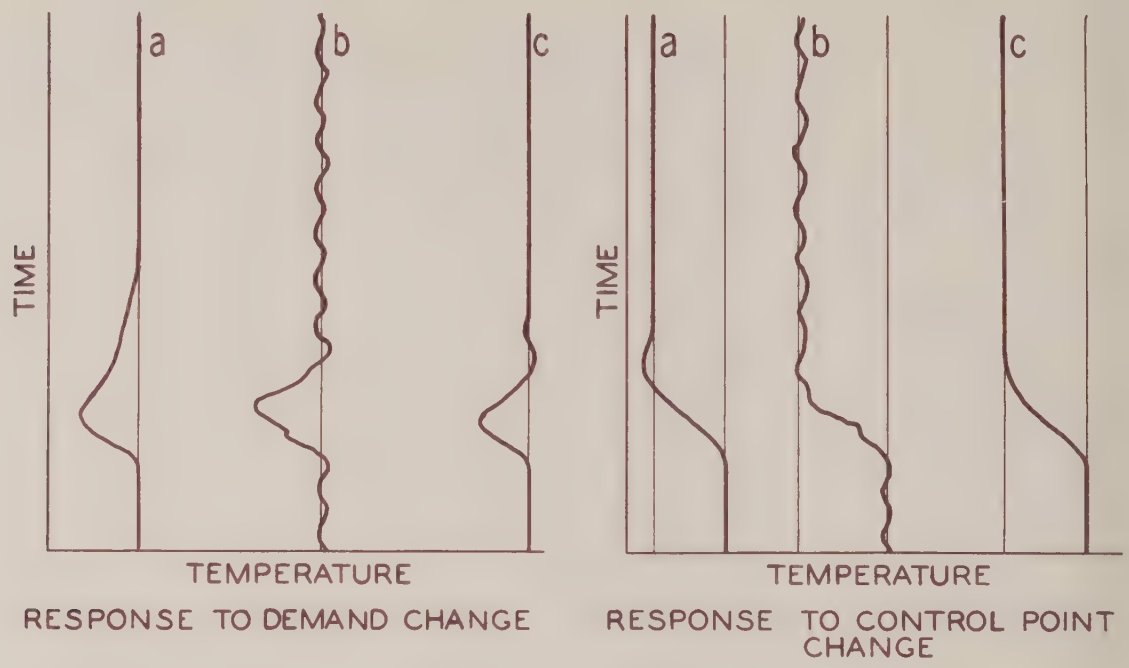


Fig. 10
Effect of Reset Adjustment in proportional-plus-reset-plus-rate control: Curves (a), reset too slow; curves (b), reset too fast; curves (c), reset correct.

A. Adjust Proportional Band

With RATE and RESET dials set to zero, adjust the proportional band. The usual procedure is to start with a reasonably wide proportional band (about 50 for most processes) and then decrease the setting until a cyclic control record results. It is recommended that small control point changes be made after each adjustment, in order to throw a small upset on the system to reveal any tendency to cycle. Once a cycle is obtained, note the approximate frequency of the cyclic response, and then widen the proportional band until the cycle disappears.

The effects of various proportional band settins are shown in Fig. 1.

NOTE ON PROPORTIONAL BAND ADJUSTMENTS

When making controller adjustments, it should be observed that a change in PROPORTIONAL BAND setting produces a corresponding change in % ON time. If the reset rate is sufficiently high, this change is temporary and causes no change (or only a small pip) in the control record. However, when reset rate is low the change will persist, thereby producing a persistent shift in the control record. With zero reset action, this shift will be permanent.

Consequently, when making adjustments as instructed in Sections 11A

and 11B, the operator should expect a shift in the control record after each change of the PROPORTIONAL BAND dial setting. This shift must be distinguished from the cycling action produced by a too-narrow proportional band setting. Confusion of these conditions will be avoided if sufficient time is allowed for the system to stabilize after each adjustment.

B. Introduce Rate Action

Now introduce the minimum amount of rate action by turning the RATE knob to .01. To determine the effect of this rate action, throw minor upsets into the system by making small changes in the control point. If an oscillation, which is somewhat faster in frequency than the oscillation caused by a too narrow proportional band, develops in the system, the process is obviously one which will not take rate action. In this case, turn the rate dial back to zero and proceed with the reset adjustment as instructed in C below.

It is advisable, particularly on complicated processes, to watch the effects of control adjustment on the other controllers on the process. When small changes in control point are made in a system utilizing rate action, a relatively large change in percent ON time may result. It is possible (but not common) for this to upset other controllers on the same process so badly as to indicate that rate action should not be used. In this instance also, the RATE dial should be turned back to zero.

Assuming that neither of the above conditions exist, the rate time should be progressively increased. Minor upsets should be introduced into the system to check the effect of each increase.

Normally, as rate action is introduced, a further reduction may be made in the proportional band width. Thus the adjustment becomes an increase in rate time and a decrease in proportional band width.

While making the foregoing adjustments, carefully observe the control record. It is important to note the frequency of any oscillations which may occur. An oscillation of about the same frequency as those obtained during the proportional band adjustment indicates that the proportional band is too narrow and should be increased. An oscillation which is appreciably faster indicates that rate time is too long and should be decreased.

Fig. 2 illustrates the results which might be expected in this stage of adjustment.

C. Add Automatic Reset

After the adjustments of the proportional band and rate time have been made, automatic reset should be introduced into the control action. The desirable setting is the maximum reset rate which the process will stand, so that the recorder pen may be returned to the control point as rapidly as possible after an upset. It is emphasized, however, that as the reset rate is increased, the basic stability of the control action is decreased. In

general, the product of the RESET and RATE TIME dial settings should not exceed 1.0. Thus, if the RATE TIME setting is 2, the RESET setting probably should not appreciably exceed 0.5.

As the reset rate is increased, the control record must again be carefully observed. The appearance of a cycle which is considerably slower than that resulting from a too narrow proportional band is a definite indication that the reset rate is excessive and should be reduced.

Figs. 3 and 4 illustrate the results of various settings in this stage of adjustment.

NOTE: High RESET dial settings (about 1.0 and higher) have the secondary effect of decreasing the proportional band width. Therefore, on processes requiring such high reset rates, the following precautions must be observed:

(a) Changing the RESET dial setting in the neighborhood of 1.0 or higher will cause an immediate change in % ON time. This change may be temporary, producing no shift (or only a small pip) in the control record, or it may start a cycling condition (see (b), below). In any event, the operator must allow sufficient time, after changing the reset setting, to determine which of these conditions develops.

(b) When the RESET dial setting is increased to (about) 1.0 or higher, the consequent decrease in proportional band width may cause cycling of the control record. This cycle will be of the same frequency as that observed during the proportional band adjustment (see 11A) and must not be confused with the slower cyclic response caused by excessive reset. Upon the appearance of such a cycle, the PROPORTIONAL BAND dial setting should be increased until the cycle disappears.

PART III

MAINTENANCE

12. PLUG-IN COMPONENTS

In the event of faulty control unit operation, the trouble can usually be eliminated simply by substituting new plug-in units for those on the chassis. Specifically, electronic tubes and electrolytic capacitors are more often subject to failure than other components. Thus it is advisable to stock spare tubes and electrolytic plug-in capacitors as an aid to servicing the equipment.

NOTE: If spare capacitors are kept on hand it is recommended that each spare be substituted for a capacitor in use at about 6-month intervals. The reason for this is that an electrolytic capacitor deteriorates if it remains unused for an extended period. Thus if two electrolytic capacitors are alternately used for about 6-month periods, a good spare will be available when wanted.

Other plug-in parts used in the control unit are the output relays and the synchronous converter. Although these sealed units are considered to be more or less permanent components, they may be readily replaced, should this become necessary. Note that the two output relays, RL and RH, are identical and are therefore interchangeable.

The Leeds & Northrup part numbers of all control unit components are given in Fig. 17. In addition, the number of each plug-in component is marked on the chassis, adjacent to the corresponding socket. When replacing such parts, always make sure they are properly seated and in the correct sockets.

13. TROUBLE SHOOTING

In the event of control unit failure which cannot be corrected by replacement of plug-in components, the best procedure is to isolate the fault to one of the major circuit sections. Then the exact location of the fault within the section can usually be determined by means of voltage and resistance checks. Details of the isolation procedures will be described.

A. Test Equipment

(1) Volt-ohmmeter Analyzer

This unit is required for checking a-c and d-c voltage and resistance values. The analyzer should have 20,000 ohms per volt impedance on the d-c voltage ranges and 1000 ohms per volt impedance on the a-c ranges, since the voltages given in this booklet are obtained with a meter having these impedances. The Simpson Model 260 analyzer has the required characteristics. If a lower impedance voltmmeter is used in measuring voltages across high resistance circuits, lower readings must be expected,

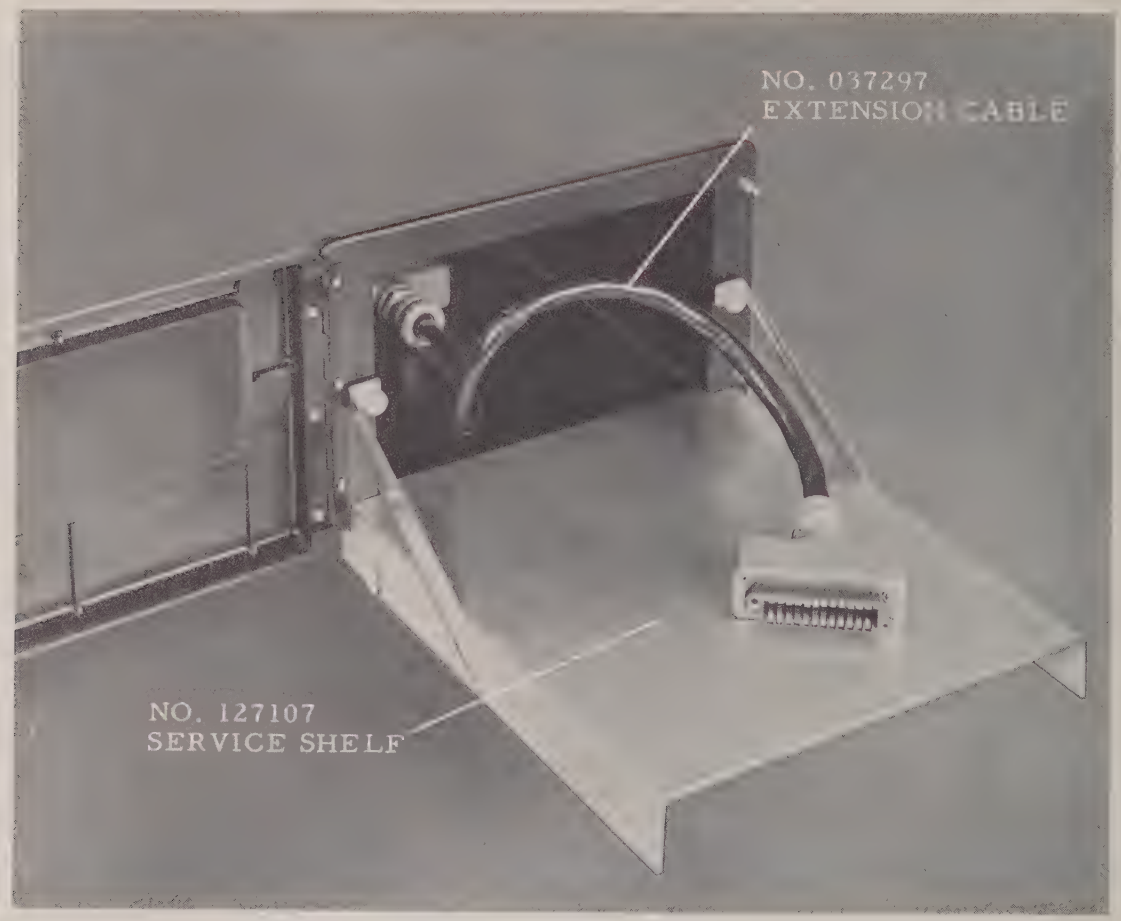


Fig. 11 - Panel mounted control unit case with shelf and cable attached for servicing.

and conversely.

(2) Special Test Equipment

The following equipment items, which may be purchased from Leeds & Northrup Company, have been designed to facilitate testing and servicing of Series 60 control systems.

(a) No. 127107 Service Shelf - This shelf attaches to the front of the control unit case, as illustrated in Fig. 11. It forms a convenient table on which to place the chassis for testing and servicing.

(b) No. 037279 Extension Cable - This extension cable is terminated with suitable plugs for connecting between the control unit chassis and case. It permits tests to be made while the control unit chassis is connected into the system as for normal operation. Fig. 11 shows the extension cable plugged into the case.

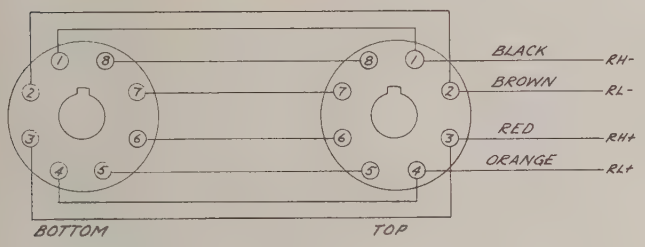


Fig. 12 - Schematic wiring of No. 037278 Socket Adaptor and Cable

(c) No. 037278 Socket Adaptor and Cable - The circuit of this device is shown in Fig. 12. The octal socket adaptor is for insertion under the No. 023027 capacitor on the control unit chassis. When so inserted, the voltages across the RL and RH relay coils can be measured at the ends of the cable leads. These leads are equipped with phone tips for plugging into the volt-ohm-meter analyzer. Two analyzers are required to permit simultaneous measurement of RL and RH relay coil voltages.

CAUTION

With the adaptor plugged into the 023027 capacitor socket, there are high a-c voltages between certain of the cable leads. To prevent shock (or damage due to short-circuiting), the cable leads should always be plugged into the analyzers before the adaptor is inserted.

(d) No. 037277 Socket Adaptor and Cable - The circuit of this device is shown in Fig. 13. The octal socket adaptor is for insertion under the converter on the control unit chassis and when so inserted, it disconnects the usual input signal from the control unit amplifier. A known d-c millivolt signal, from a portable potentiometer or other convenient source, can then be applied to the amplifier input through the cable leads. This permits the amplifier to be tested independently of the remainder of the control system.

(e) No. 040223 Socket Adaptor - The circuit of this octal socket adaptor is shown in Fig. 14. When inserted under the converter on the control unit chassis, the adaptor disconnects the feedback circuit from one side (pin 4) of the converter and connects this side to ground. The amplifier input then consists only of the control bridge unbalance signal. This permits testing of the control bridge and amplifier together.

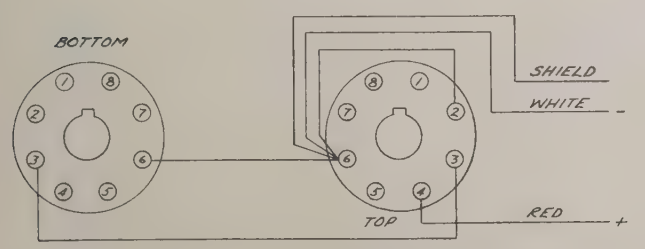


Fig. 13 - Schematic wiring of No. 037277 Socket Adaptor and Cable

B. Amplifier Test

To test the control unit amplifier only, proceed as follows:

1. Connect the control unit chassis into its case, using the No. 037279 extension cable, and set the IMPULSE

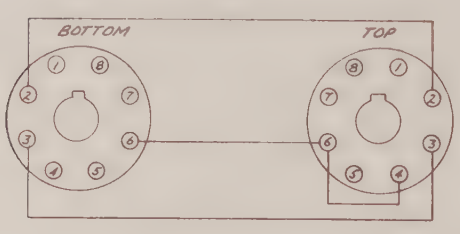


Fig. 14 - Schematic wiring of No. 040223 Socket Adaptor and Cable.

FREQUENCY dial to 10. Settings of other dials are immaterial.

2. Insert the No. 037277 adaptor and cable under the converter on the chassis. Connect the cable leads to the emf terminals of a portable potentiometer (such as the Leeds & Northrup No. 8657-C). Short-circuit or clamp the galvanometer of the potentiometer.

3. Plug the RH leads of the No. 037278 adaptor and cable into a voltohmmeter analyzer and plug the RL leads into a similar analyzer. Set both analyzers to the 50 V d-c range. Then insert the adaptor under the No. 023027 capacitor.

4. Adjust the portable potentiometer dial to obtain equal readings on both analyzers (note that it may be necessary to reverse the potentiometer connections). This common reading is a measure of amplifier "noise" and should not exceed 5 volts.

A high amplifier noise level may be caused by incorrect bias in the V_3 stage (the correct V_3 bias, measured from ground to cathode, is given in Fig. 16). Other possible causes of excessive noise are (a) converter driving voltage too low, and (b) incorrect converter closure time. The a-c driving voltage is measured between the chassis and the yellow lead to the converter top plug (without disconnecting this plug) and should be 20 $\pm$ 3 V a-c. For instructions on checking and adjusting converter closure times, refer to Section 14.

5. With equal analyzer readings, as in the preceding step, note the millivolt setting of the portable potentiometer. This setting is equal to the amplifier "zero offset" and should not exceed .5 mv. Excessive offset may be due to incorrect converter phasing. Check phasing components R3 and C5.

With the same test arrangement as specified in (1) above, adjust the portable potentiometer to obtain a reading of 30 V on one of the analyzers. Note the potentiometer setting required for this condition. Then reverse the connections to the potentiometer, adjust it until the other analyzer reads 30 V, and again note the potentiometer setting.

The sum of the two settings noted above is defined as the amplifier dead band. Its magnitude should not exceed 3 millivolts.

Excessive dead band may be caused by any fault which decreases amplifier gain. Such faults can usually be located by a systematic check of amplifier voltages and resistances. Another possible cause of wide amplifier dead band is incorrect converter closure time (see Section 14).

C. Control Circuit Test

Although the following test involves both the amplifier and the control circuit, it is effectively a test of the control circuit only, since the amplifier is assumed to have been tested as described above.

To make the test, connect the No. 037278 adaptor and cable and the two analyzers as instructed in the preceding section. Then insert the No. 040223 socket adaptor under the converter. Set AUTO-MAN switch to AUTO and set other dials as follows:

IMPULSE FREQUENCY	10
PROPORTIONAL BAND	500
RATE TIME	0
RESET	.01

First line up the red and black pointers of the recorder. This should produce equal readings of both analyzers, if the control slidewire has been properly adjusted as directed in Section 10A. Moreover, the reading of each analyzer should not exceed 5 V. If the readings are unequal, adjust the slidewire, while keeping the red and black pointers together, until equal analyzer readings are obtained. If the common analyzer reading is greater than 5 V, the converter should be checked as instructed in Section 14.

Now, displace the recorder reading downscale until one of the analyzers (that connected to the RL leads) reads 30 V. Note the recorder reading. Move the black pointer upscale until the other analyzer reads 30 V and again note the recorder reading. The difference between the two readings just noted should not exceed 5% of the recorder scale span.

If the relay voltages do not respond to changes in the recorder reading, or if the condition specified above is not met, then the trouble is in the control bridge circuit. Check voltages and resistances of the control slidewire and its voltage supply, and associated components.

D. Check Relay Action

With connections as in the preceding section, displace the recorder reading below the control point until the RL analyzer reads 30 V. The amber light on the chassis front panel should be on. When the recorder is brought back to control point, the light should remain on.

Now displace the recorder reading above the control point until the RH analyzer reads 30 V. The amber light should be off and should remain off when the recorder is returned to control point.

Failure to meet the above conditions may be due to a faulty plug-in relay RL or RH. Another possible source of trouble is a faulty or improperly connected external relay AR.

E. Check Feedback Circuit

If tests up to this point have not located the trouble, the fault is prob-

Fig. 15 - Location of converter adjustment hole. Other hole is diametrically opposite hole shown.

ably in the feedback circuit. This circuit comprises capacitors C-1 and C-2 and the regulated and filtered supply from which these capacitors are charged. Relay BR (together with R1 and R14), and reset resistors R35 to R51 are also included in the feedback circuit. Systematic checking of voltages and resistances in the feedback circuit will locate the faulty component.

F. Voltage And Resistance Measurements

All measurements are to be made under the conditions noted in Fig. 16. If dial settings and other conditions are not as specified, then some voltages and resistances can be expected to differ from the values given.

Note that RL, RH, and BR are all No. 036200 relays. These relays contain mercury which short-circuits the contacts when the relays are inverted. As stated in note 4 of Fig. 16, this causes the normal on-off action of the control unit to stop.

G. Replacing Components

When faulty parts are replaced, the new parts and wiring must conform exactly to the original arrangement. When resoldering, use no more solder than necessary to produce a satisfactory connection.

14. CHECK AND ADJUST CONVERTER

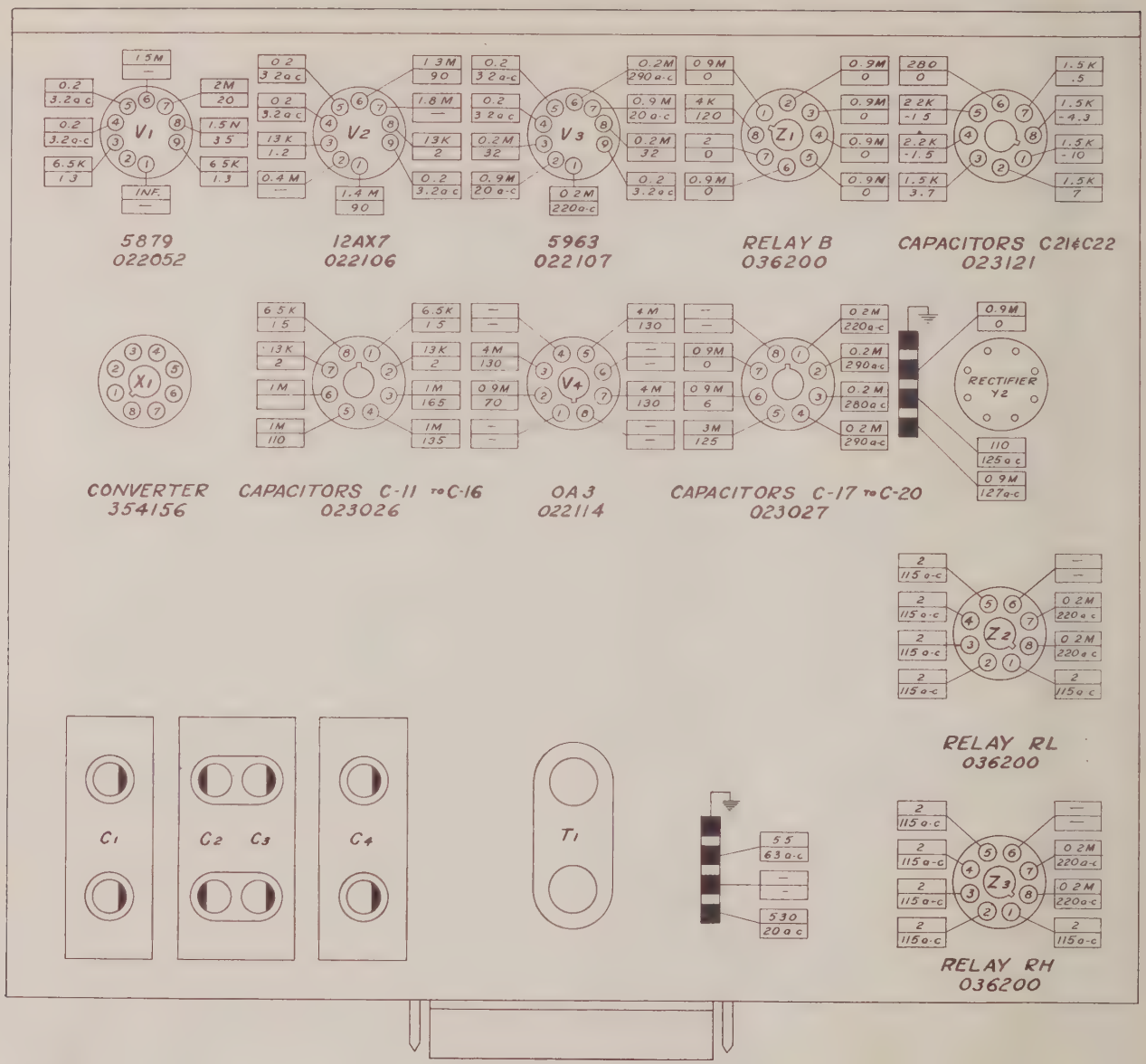
To measure closure time of the converter contacts, first remove the converter from its socket but leave the top plug connected. Connect a volt-ohmmeter analyzer (ohms x 100 range) between pins 2 and 3 of converter base. With the converter held upright and the analyzer laid flat on a horizontal surface, note the analyzer reading on the 0-100 d-c volts scale. Connect the analyzer between pins 3 and 4 of the converter base and again note the reading. These readings are equal to the percentage closure times of contacts 3-2 and 3-4 respectively, and should be within the limits 35-45.

If converter closure times are not within the specified limits, the converter can be adjusted.

Use a sharp instrument to punch two holes in the metal label of the

converter at the points indicated in Fig. 15. With the analyzer connected to measure contact closure, as described above, use a #6 hex socket set screw wrench to turn the adjusting screws (accessible through the holes) until closure time is 40% for each set of contacts. The front adjustment (facing the viewer in Fig. 15) controls closure time between pins 3 and 4. Turning the adjusting screw clockwise decreases closure time, and conversely.

IMPORTANT: After adjusting the converter, use a piece of non-magnetic metallic tape to seal the holes in the case. This is essential, since the entrance of even small amounts of dust may render the converter unusable.



NOTES:

1. Lower section of each block gives voltage to chassis; upper section gives resistance to chassis.
2. Voltages are d-c except as indicated. These are average values to be obtained with 115 V a-c line voltage.
3. Unit is to be connected as for normal operation. Observe grounding instructions given on installation wiring diagram.
4. Measurements to be made with chassis inverted. Note that this stops on-off action and keeps external relay AR continuously energized.
5. Line voltage compensator switch (under chassis) to be on "E".
6. Control slidewire contact to be at high end of slidewire.
7. Control panel settings to be as follows:

AUTO-MAN Switch	AUTO	RATE	0
IMPULSE FREQUENCY	10	RESET	0
PROPORTIONAL BAND	500		

8. Abbreviations as follows: M = megohm; K = thousand ohms; INF = infinite.

Fig. 16 - Control unit voltages and resistances

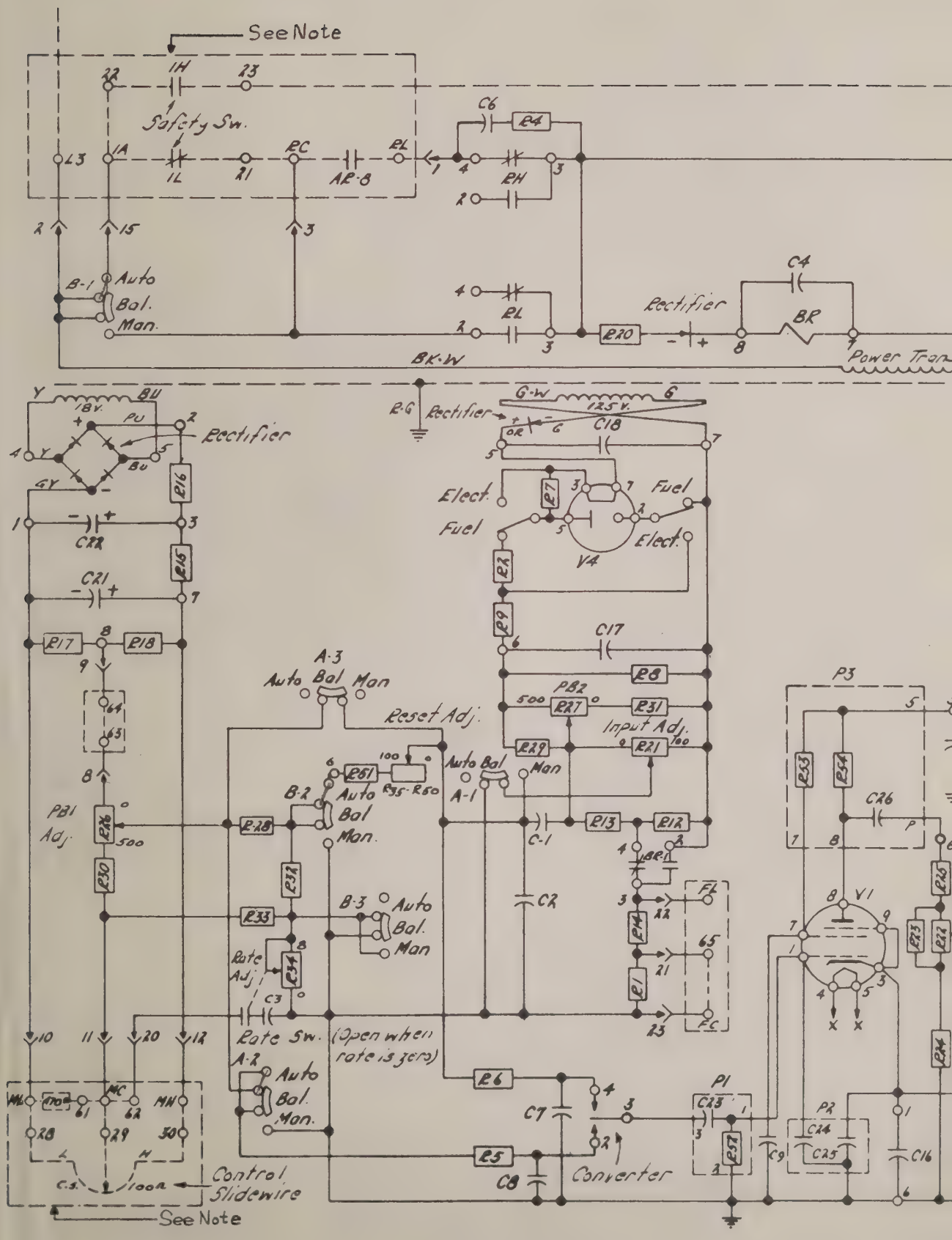
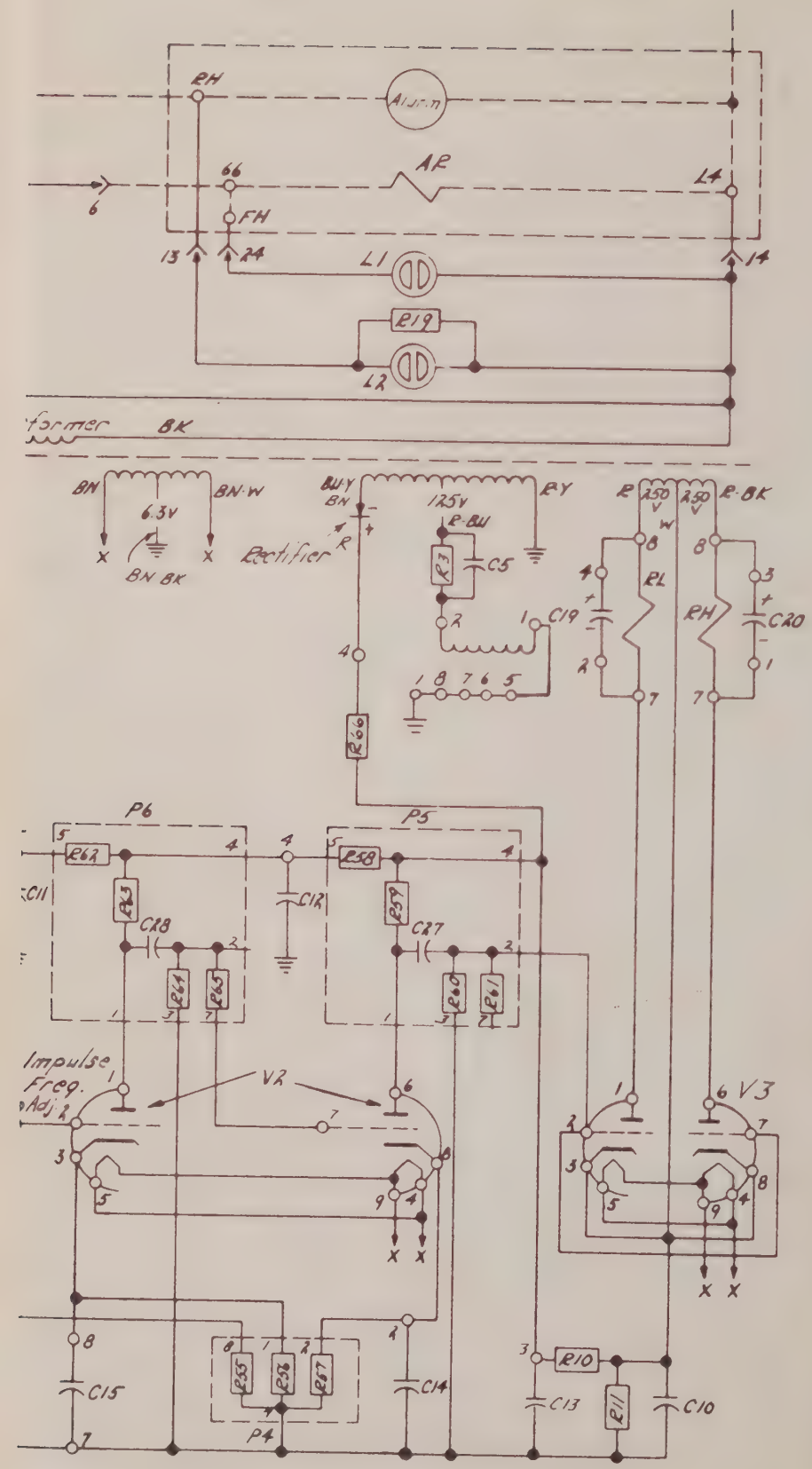


Fig. 17 - Elementary wiring diagram of 3-actio



D.A.T. control chassis

NOTE: Terminal and switch designations in external equipment (shown dotted) apply to Speedomax H. For designations on Speedomax G or Micromax, refer to installation wiring diagram.

RESISTORS*

	Part No.
R1 = 1M	011180
R2 = 1K	011144
R3 = 2.7K 2W	011362
R4 = 39 Ω	011127
R5 = 2.2M	011184
R6 = .47M	011176
R7 = 1.5K 5W	011478
R8 = 1.2K	011145
R9 = 4.7K 1W	011261
R10 = .82M	011179
R11 = .22M	011172
R12 = .10M	011168
R13 = 2.2K	011148
R14 = 10 M	011192
R15 = 22 Ω 1W	011490
R16 = 22 Ω 1W	011490
R17 = 510 Ω, R18 = 510 Ω	011456
R19 = 1M	011180
R20 = 2.2K	011148
R21 = 10K	013048
R22 = 1M	013143
R23 = .47M	011176
R24 = 15K	011158
R25 = 1M	011180
R26 = 2K, R27 = 10K	013140
R28 = 820 Ω	011143
R29 = 22K	011160
R30 = 270 Ω	011486
R31 = 100 Ω	011132
R32 = 180 Ω	011135
R33 = 10K	011156
R34 = 2M	013141
R35 = 68M	011489
R36 = 27M	011488
R37 = 22M	011196
R38 = 10M	011192
R39 = 6.8M	011190
R40 = 2.7M	011487
R41 = 2.2M	011184
R42 = 1M	011180
R43 = .68M	011178
R44 = .27M	011173
R45 = .22M	011172
R46 = .1M	011168
R47 = 68K	011166
R48 = 27K	011161
R49 = 22K	011160
R50 = 10K	011156
R51 = 15K	011158
R66 = 2.7K	011149

▼

CAPACITORS

			Part No.
C1 =	10μf	10V DC	023118
C2 =	24μf	5V DC	023119
C3 =	24μf	5V DC	
C4 =	5μf	100V DC	023120
C5 =	.5μf	200V DC	023052
C6 =	.02μf	2000V DC	023059
C7 =	.05μf	400V DC	023038
C8 =	.05μf	400V DC	023038
C9 =	.1μf	400V DC	023037
C10 =	.5μf	200V DC	023052
C11 =	4μf	200V DC	023026
C12 =	4μf	200V DC	
C13 =	4μf	200V DC	
C14 =	25μf	2V DC	
C15 =	25μf	2V DC	
C16 =	25μf	2V DC	
C17 =	50μf	35V DC	023027
C18 =	12μf	210V DC	
C19 =	4μf	300V DC	
C20 =	4μf	300V DC	
C21 =	1000μf	12V DC	023121
C22 =	500μf	20V DC	

PRINTED CIRCUITS

P1	R52 = 82M, C23 = .002μf	144010
P2	C24 = .001μf, C25 = .001μf	023125
P3	R53 = 2.2M, R54 = .47M, C26 = .022μf	144012
P4	R55 = 6.8K, R56 = 15K, R57 = 15K	144011
P5	R58 = .10M, R59 = .47M, R60 = 1M, R61 = 1M, C27 = .022μf	144013
P6	R62 = .10M, R63 = .47M, R64 = 1M, R65 = 1M, C28 = .022μf	144013

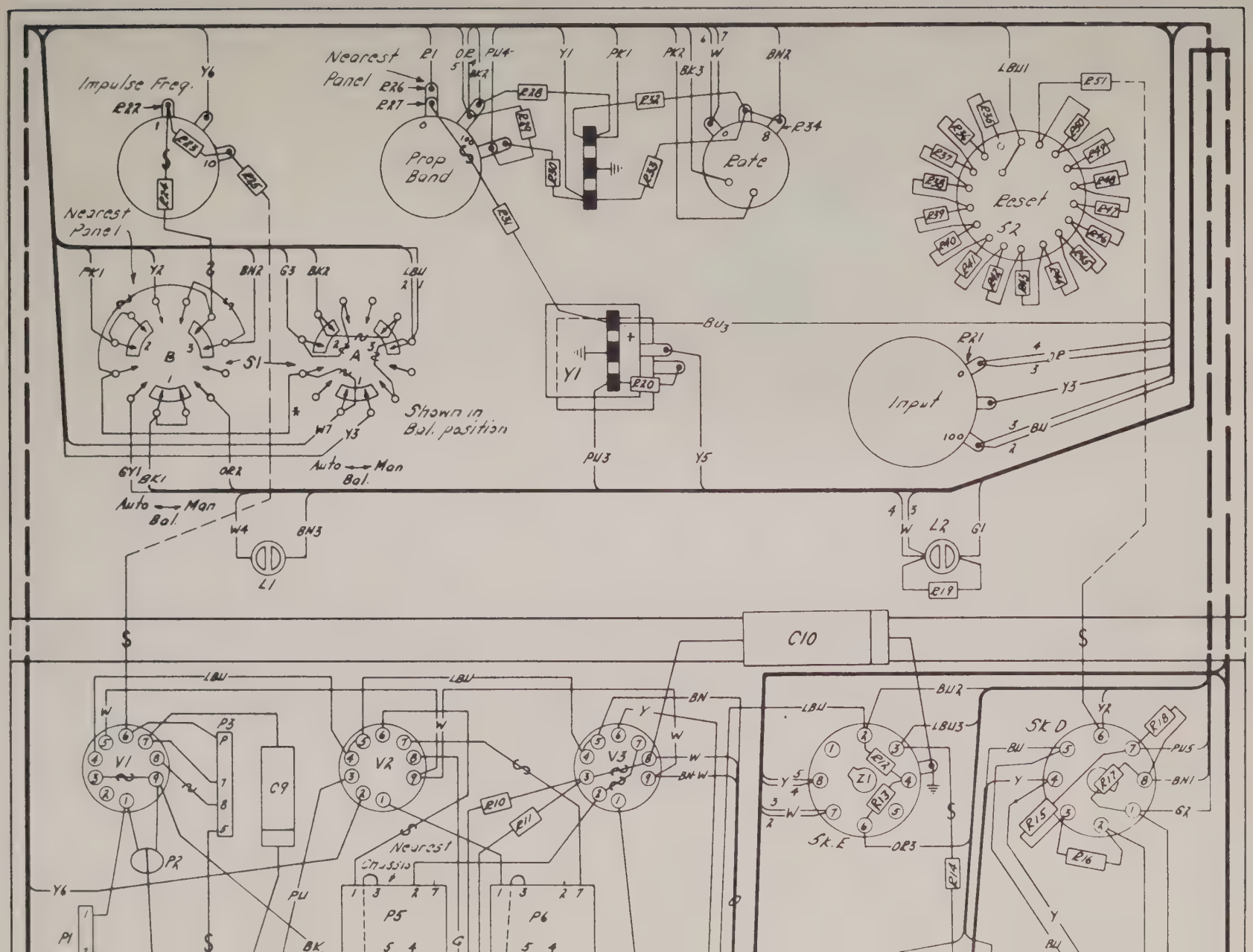
MISCELLANEOUS

V1	5879 Tube	022052	T1	Transformer	019184
V2	12AX7 Tube	022106	S1	Man-Auto Sw.	031135
V3	5963 Tube	022107	S2	Reset Sw.	032182
V4	OA3 Tube	022114	S3	Fuel-Elect. Sw.	032197
X1	Converter**	354156	L1	Amber Light	026107
Y1	65 mil. Rectifier	057103	L2	Red Light	026108
Y2	Rectifier	057015	N1	Low Level Cable	037335
Z1	BR Relay	036200	N2	High Level Cable	
Z2	RL Relay	036200	N3	Converter Cable	037253
Z3	RH Relay	036200			

*All resistors are 1/2 watt with ± 10% tolerance except as specified.

**For chassis 354165 only. Converter for chassis 354182 is Part #354169.

▼ Supplied as parts of S2.


Impulse Freq.
Nearest Panel
Prop Band
Rate
Reset S2
Input
Shown in Bal. position
Auto — Man Bal.
Nearest Chassis
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
S20
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S44
S45
S46
S47
S48
S49
S50
S51
C9
C10
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
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P26
P27
P28
P29
P30
P31
P32
P33
P34
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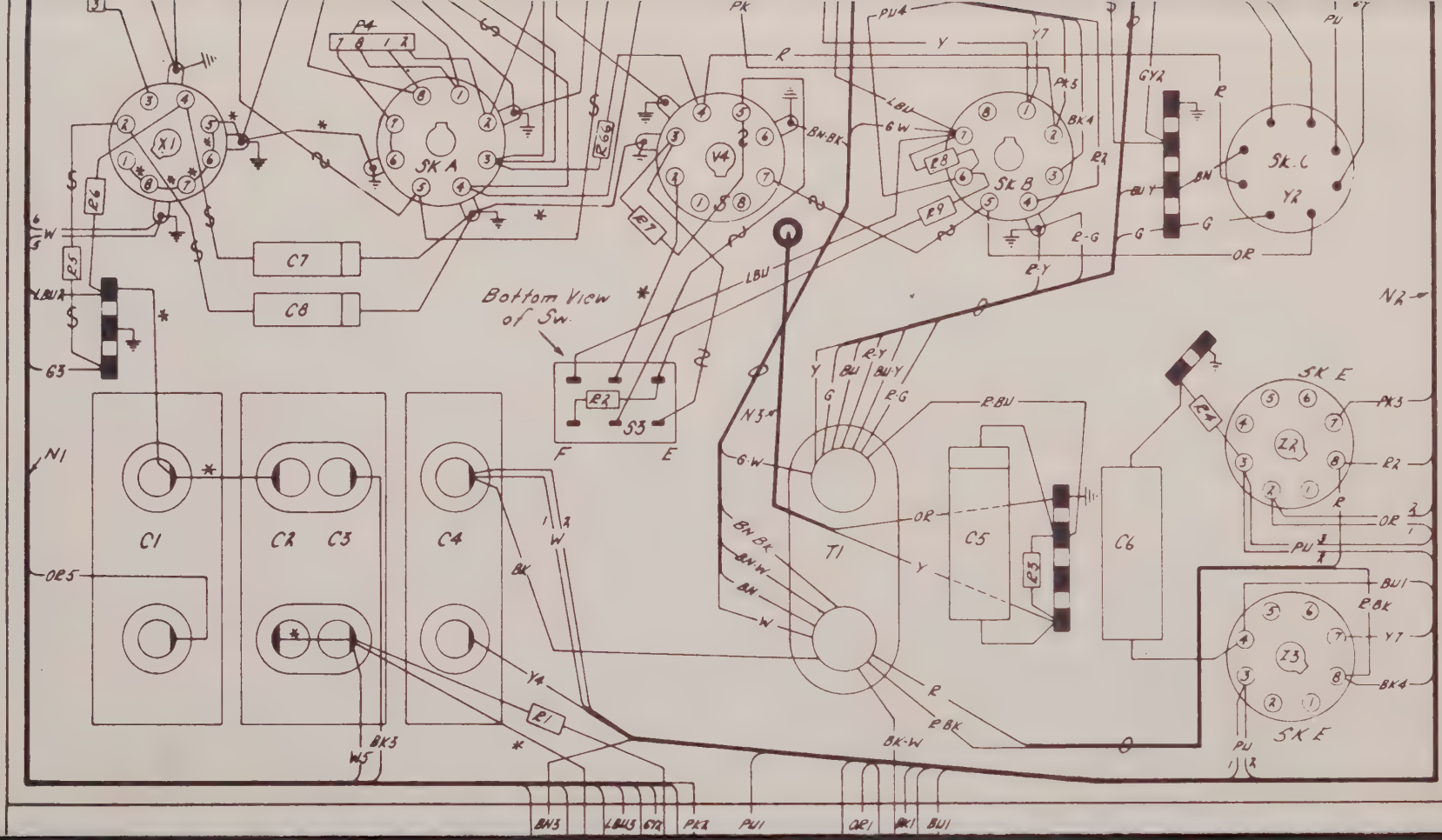
V2
V3
Z1
Y1
Y2
Y3
Y4
Y5
Y6
Sk. D
Sk. E


X1
SK A
P4
R66
V4
E7
E6
E5
C7
C8
Bottom View of Sw.
S3
E2
F
E
SK B
E8
E9
SK C
Y2
GY2
E4
SK E
Z2
Z3
C1
C2
C3
C4
C5
C6
T1
E1
E3
N1
N2
N3
63
6 W
LBU
R
Y
Y7
PK
PU4
PK3
BK4
BU1
P BK
BK-W
BN-BK
BN-W
BN
W
OR
P-Y
P-G
BU-Y
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OR5
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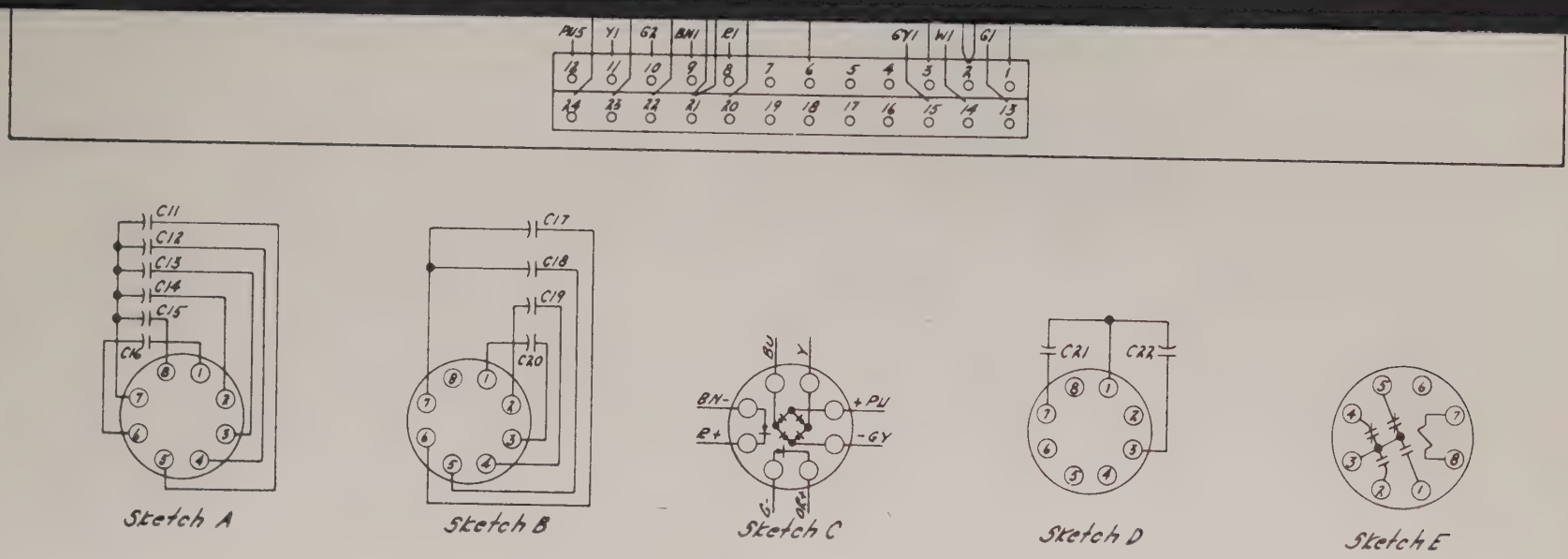
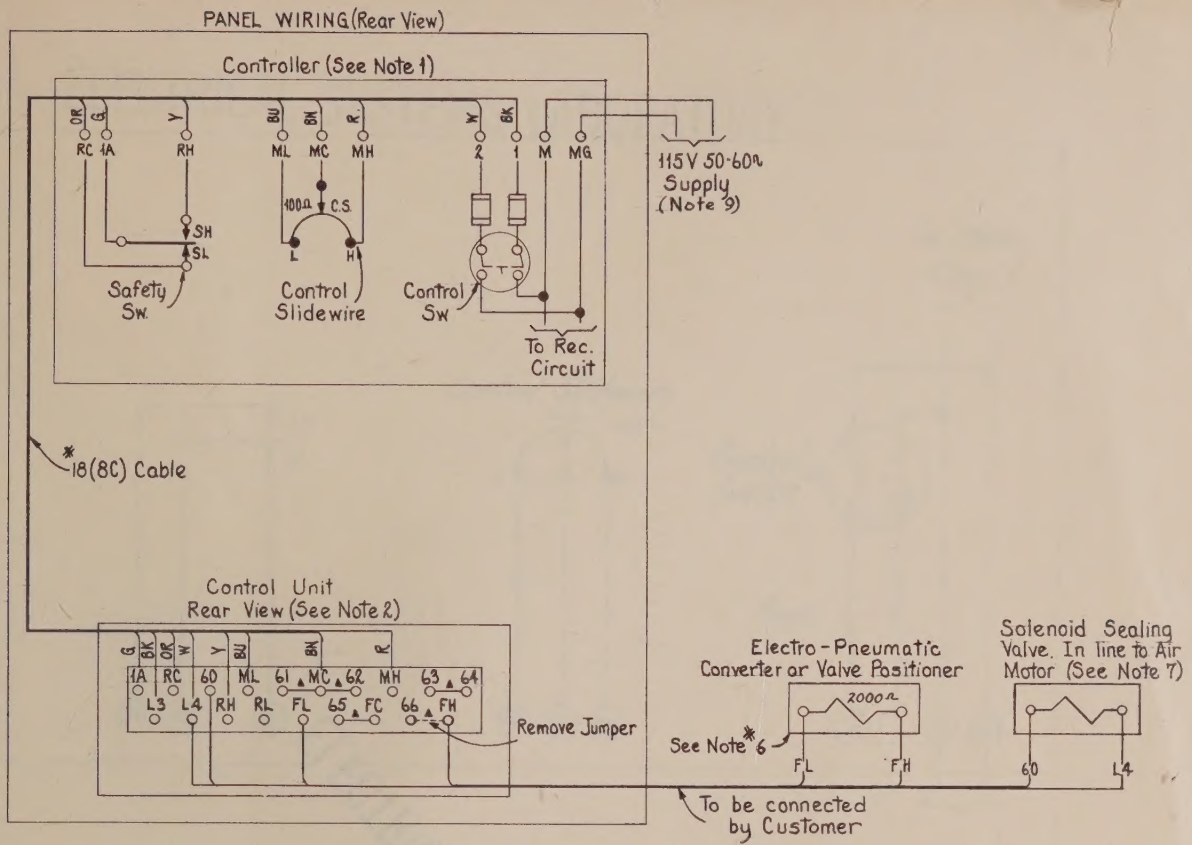
G72
PK2
PU1
OR1
BK1
BU1



NOTES:

- ⊕ Indicates tightly twisted leads
- ⊖ Indicates insulating tubing
- ⊓ Indicates outside foil of paper capacitors
- ⊕ Indicates tightly twisted leads in cable

Fig. 18 - Actual wiring of 3-action D.A.T. control unit chassis

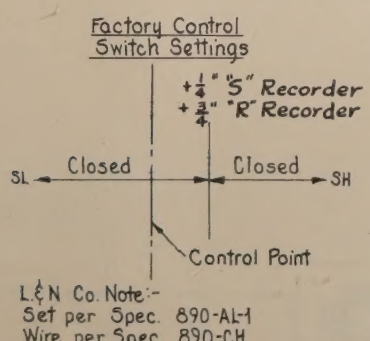

PANEL WIRING (Rear View)
Controller (See Note 1)
OR G Y BU BN R W BK
RC 1A RH ML MC MH 2 1 M MG
115 V 50-60~ Supply (Note 9)
100Ω C.S.
SH
SL
L
H
T
Safety Sw.
Control Slidewire
Control Sw.
To Rec. Circuit
*18(8C) Cable
Control Unit
Rear View (See Note 2)
G BK OR W Y BU BN R
1A RC 60 ML 61 MC 62 MH 63 64
L3 L4 RH RL FL 65 FC 66 FH
Remove Jumper
Electro-Pneumatic Converter or Valve Positioner
2000Ω
See Note *6
FL FH
Solenoid Sealing Valve. In line to Air Motor (See Note 7)
60 L4
To be connected by Customer

ELECTRICAL SYSTEMS LABORATORY

Notes:-

1. For Controller measuring circuit connections see separate diagram.
2. For Control Unit internal wiring see separate diagram.

3. Wired as shown, when Controller indicator pointer moves to left side of Control Point output current increases & position meter goes towards 100. Safety action operates to cut off current.
4. To reverse control action interchange leads ML with MH & RC with RH. *Set safety switch to operate near low end of control slidewire. See directions for reversing manual setter markings.*
5. Factory safety switch setting is as indicated. *It may be set closer to but not beyond the high end of the control slidewire.*
6. For lower resistance converter or positioner add suitable resistor in series with lead to FL to make total resistance 2000Ω. (Approx.)
7. Sealing Valve, if used, holds control valve in fixed position following current interruption to converter or valve positioner coil. If not used omit external connections to terminals L4 & 60.
8. See directions for reversing meter markings
9. *MG side of line must be grounded. If power supply cannot be grounded, add isolating transformer and ground MG terminal.*



L&N Co. Note:-
Set per Spec. 890-AL-1
Wire per Spec. 890-CH

Cable Color Code	
BK-Black	BU-Blue
W-White	BN-Brown
G-Green	OR-Orange
R-Red	Y-Yellow

▲ Metal Jumper

IND. ENG. NO.

NO.	DATE	APP.	REVISIONS
1	2-21-55		A19004
2	2-26-55		(A21292)
3	1-11-56		(A25089)
4	4-18-56		(A25741)

SERIES 60 CONTROL-SINGLE POINT
CAT 10877 WITH
ELECTRO-PNEUMATIC CONVERTER

DR. Flannery	CH. Grant	DATE 1-31-55
DESIGN	DESIGN APP.	APPROVED
FIRST MADE FOR L & N ORDER NO.		JOB NO.

DWG. NO. B-MSS-77-AA-10

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